



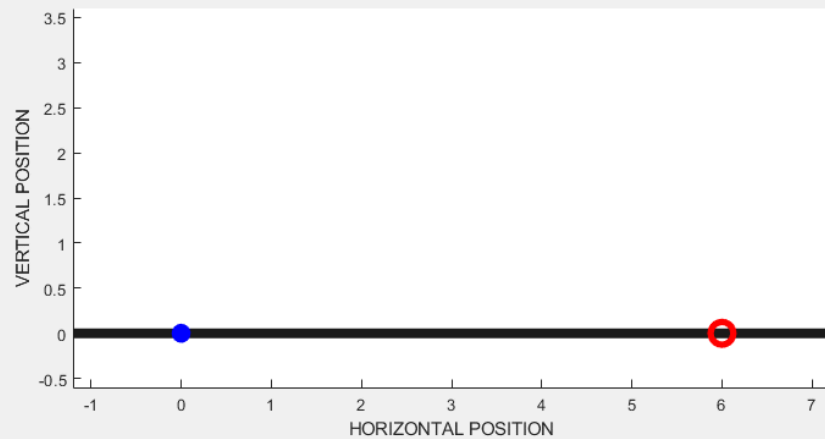
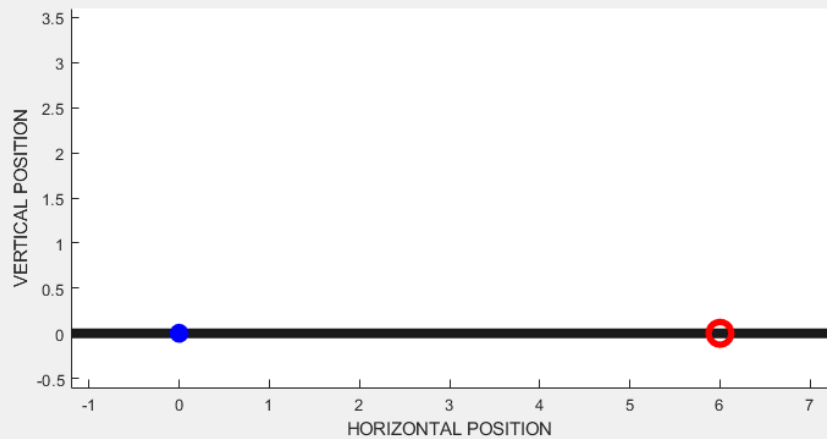
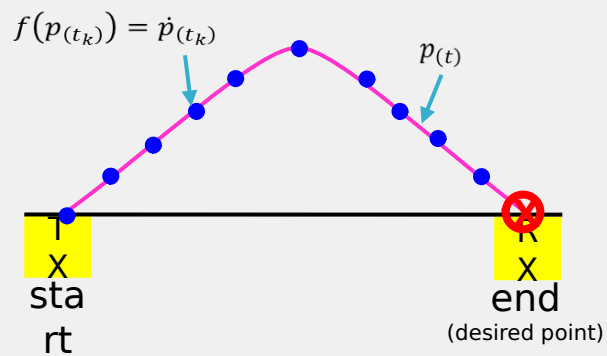
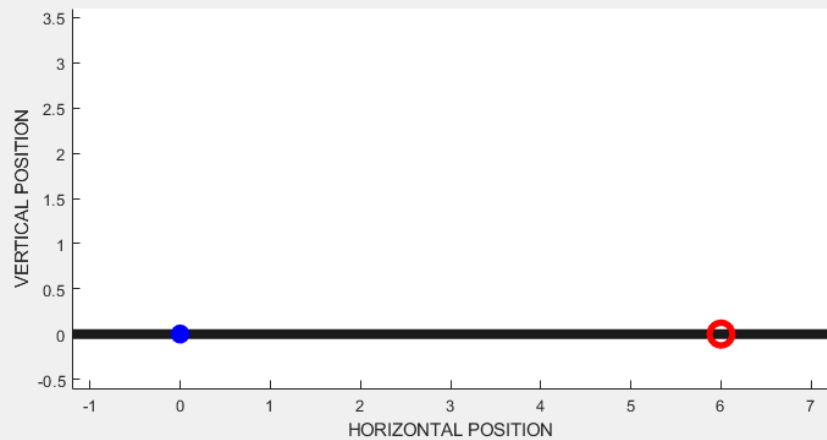
HamSCI Workshop 2022

IONOSPHERE PLASMA DENSITY ESTIMATION BY RAY TRACING OPTIMIZATION

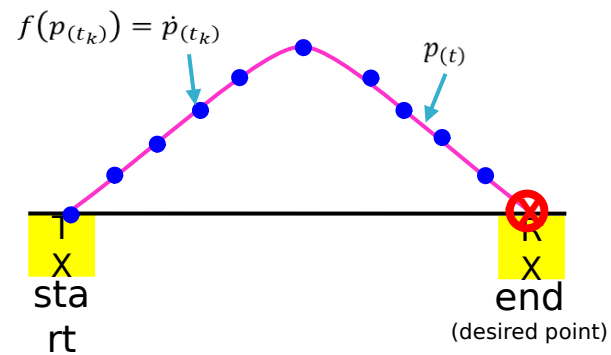
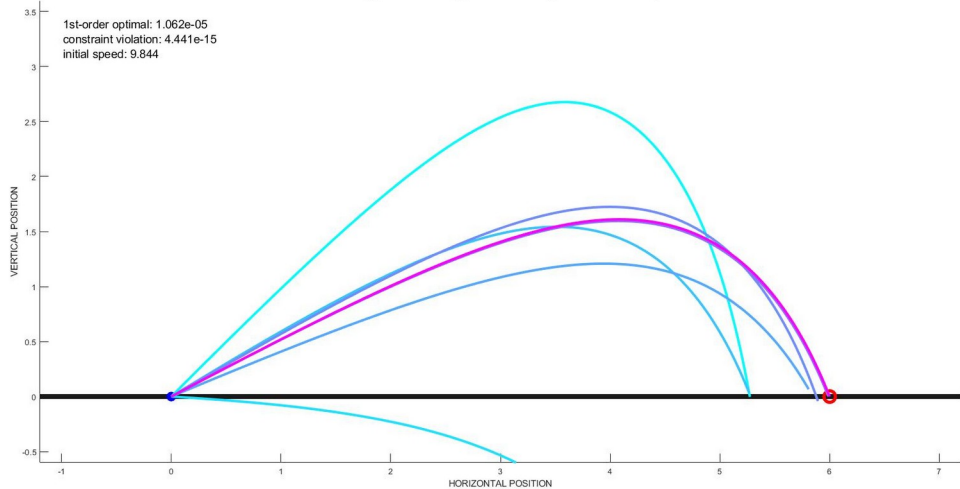
David de la Torre ¹, Enrique Rojas ², Marco Milla ¹

¹ Pontifical Catholic University of Peru, Lima, Peru

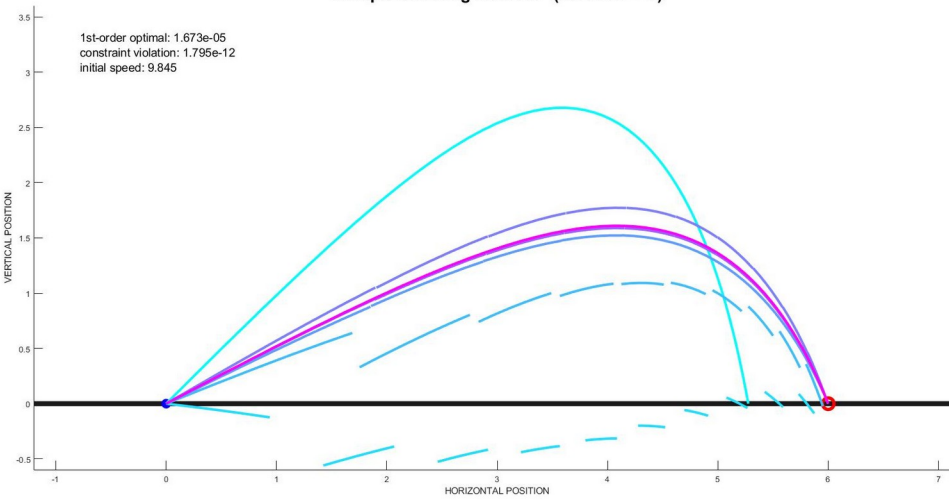
² Cornell University, New York, USA



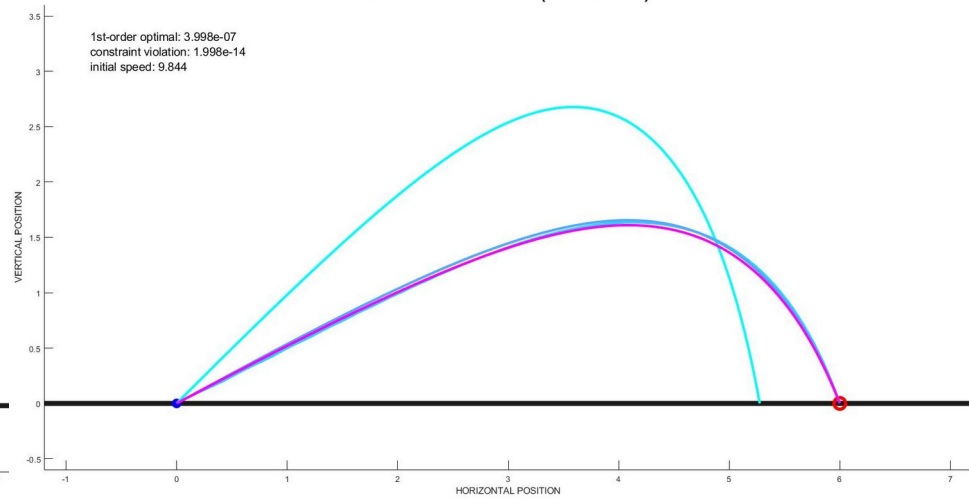
Single Shooting Method: (iteration = 10)



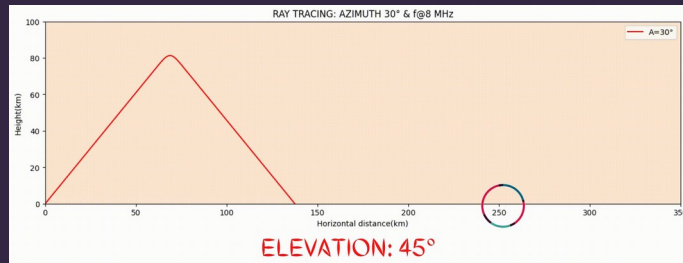
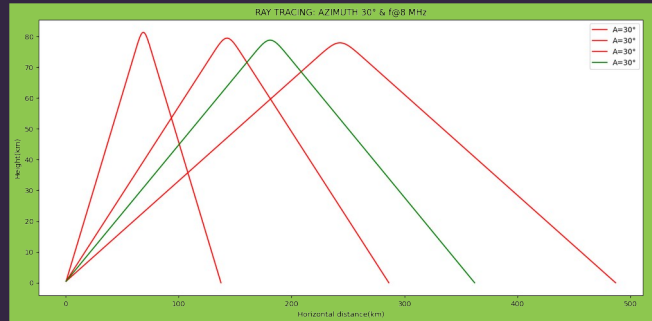
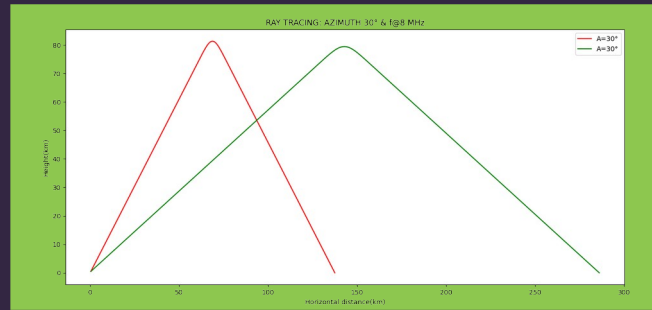
Multiple Shooting Method: (iteration = 9)



Collocation Method: (iteration = 7)



ITERATIVE METHOD



```
1 bisection(f, 5, 85, tol=10**-3, n=500)
```

```
ite 1 : a_0 =5.0000000 , b_0 =85.0000000 , c_1 =45.0000000
ite 2 : a_1 =5.0000000 , b_1 =45.0000000 , c_2 =25.0000000
Solution found elevation =25.0000000
25.0
```

```
1 bisection(f, 5, 85, tol=10**-3, n=500)
```

```
ite 1 : a_0 =5.0000000 , b_0 =85.0000000 , c_1 =45.0000000
ite 2 : a_1 =5.0000000 , b_1 =45.0000000 , c_2 =25.0000000
ite 3 : a_2 =5.0000000 , b_2 =25.0000000 , c_3 =15.0000000
ite 4 : a_3 =15.0000000 , b_3 =25.0000000 , c_4 =20.0000000
Solution found elevation =20.0000000
20.0
```

```
1 bisection(f, 5, 85, tol=10**-3, n=500)
```

```
ite 1 : a_0 =5.0000000 , b_0 =85.0000000 , c_1 =45.0000000
ite 2 : a_1 =5.0000000 , b_1 =45.0000000 , c_2 =25.0000000
ite 3 : a_2 =25.0000000 , b_2 =45.0000000 , c_3 =35.0000000
ite 4 : a_3 =25.0000000 , b_3 =35.0000000 , c_4 =30.0000000
ite 5 : a_4 =25.0000000 , b_4 =30.0000000 , c_5 =27.5000000
ite 6 : a_5 =27.5000000 , b_5 =30.0000000 , c_6 =28.7500000
ite 7 : a_6 =27.5000000 , b_6 =28.7500000 , c_7 =28.1250000
ite 8 : a_7 =27.5000000 , b_7 =28.1250000 , c_8 =27.8125000
ite 9 : a_8 =27.8125000 , b_8 =28.1250000 , c_9 =27.9687500
ite 10 : a_9 =27.9687500 , b_9 =28.1250000 , c_10 =28.0687500
ite 11 : a_10 =27.9687500 , b_10 =28.0687500 , c_11 =28.0781250
ite 12 : a_11 =27.9687500 , b_11 =28.0781250 , c_12 =27.9882812
ite 13 : a_12 =27.9882812 , b_12 =28.0781250 , c_13 =27.9980469
ite 14 : a_13 =27.9980469 , b_13 =28.0781250 , c_14 =28.0029297
ite 15 : a_14 =27.9980469 , b_14 =28.0029297 , c_15 =28.0004883
ite 16 : a_15 =27.9980469 , b_15 =28.0004883 , c_16 =27.9992676
ite 17 : a_16 =27.9992676 , b_16 =28.0004883 , c_17 =27.9998779
Solution found elevation = 27.9998779, iterations: 17
27.9998779296875
```